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BRAIN MECHANISM[1]

By Dr. EDGAR DOUGLAS ADRIAN, F.R.S.

TRINITY COLLEGE, CAMBRIDGE UNIVERSITY

I CAN think of no better way of beginning than by ecalling another function due to the Pilgrim Trust t which I was present six months ago. I recall it in ratitude to a foundation which has preserved so uch that is worth preserving in Great Britain, and ecause this particular occasion concerned a scientist ho might be claimed from both sides of the Atlantic, ince he belongs to the period of our common ancestry. he occasion was the presentation by the Trust to rinity College, Cambridge, of some of the private ibrary of Sir Isaac Newton, scholar and fellow of the ollege and afterwards president of the Royal Society. he presentation was made in the great library built y Christopher Wren at the request of Isaac Barrow, he master of Trinity who recognized the genius of ewton and did all he could to foster it, and the books are now in the shelves at the south end of the library near the Newtonian telescope and the statue of Lord Byron.

The war has prevented an international celebration of three famous men who were born or died 400, 300 and 200 years ago, Copernicus, Newton and Lavoisier, and the Royal Society has been forced to honor its greatest president without the ample banquet which would normally have shown our devotion to science. But the meetings in his honor have made us more aware of those aspects of Newton's work which are overshadowed by the "Principia" and the "Optics." As far as mathematical physics was concerned Newton had only to be and all was light. But there is also the less triumphant figure, Newton the student of the occult, the interpreter of the book of Daniel, the half-believer in Hermetic secrets, who could scarcely bear to be distracted from these things by the mathematical problems which he could not resist solving, who spent the best years of his life in chemical experiments which have had no result. His

[1] The second Pilgrim Trust Lecture to be given in the United States. This address was delivered at the United States National Museum, Washington, D. C., under the auspices of the National Academy of Sciences, on April 24, 1944.

nephew, Humphrey Newton, has left us a picture of him working day and night in his rooms by the great gate of Trinity, with the furnace burning continually and the old, mouldy book on the transmutation of metals by his side. As a rule he seems to have enjoyed himself thoroughly, but it was here that ultimately the clouds gathered over his mind until his friends took him to London and gave him new and less exacting interests. It always gives me a thrill of pride to recall that I lived for four years in Newton's rooms in Trinity, but I have been glad that his great intellect had left no traces of its struggles to harass later tenants.

Stukeley in his memoir says, "As to chemistry we may presume Sir Isaac from his long application to that pyrotechnical amusement had made important discoveries in this branch of philosophy," and he repeats the story that Newton had written a treatise on chemistry which was unluckily burnt in a fire, though it seems that the little dog, Diamond, who is blamed for upsetting the candle is as apocryphal as Newton's cat and kitten. But fire or no fire Newton could scarcely have reached any general laws of chemical affinity, for so many of the relevant facts were not yet discovered. The whole mass of quantitative relations had still to be worked out, as the earlier astronomers had worked out the data of planetary motion. So Newton's natural philosophy deals only with matter in general and takes no account of chemical change.

It takes no account of life either, for Newton was not interested in living things. But I have not brought in the contrast between Newton the physicist and Newton the alchemist without a reason. It is that I proposed to talk of a subject which inherits some of the glamor of seventeenth century chemistry or alchemy. The physiology of the brain has not the economic attractions of the philosopher's stone but it has the same kind of appeal to our curiosity, to our desire to know more perhaps than is good for us. For other kinds of physiology may tell us about living matter, but the physiology of the brain might give the answer to some vital questions about our own minds and might even help to decide what sort of universe we are really in, whether it is the mechanical universe of the seventeenth century or something much more modern and uncertain.

Detailed knowledge of the brain is all of very recent date. In Newton's time it was known that the brain was in touch with the nerves from the sense organs, but up to 1860–1870 there was really nothing to show what sort of events took place in it. Then came the discovery of the speech centers by Broca and of the motor area by Hitzig and Fritsch and with that the search for mechanism in the brain could really begin. There were definite pathways and cell groups for particular operations, for the comprehension of words, for skilled movements and so on. The brain came to be thought of as a great mass of nerve cells and interlacing fibers, and the tracing of pathways through it became the main task of the neurologist. And this happened not so very long ago, for David Ferrier, one of the most successful pioneers in cerebral localization, used to visit the National Hospital at Queen Square when I was a resident there.

Between that time and the present, one of the major developments came from Sherrington's work on the spinal reflexes. This has a special claim to be mentioned here, for it was Sherrington's visit to Yale in 1905 to give the Silliman lectures which led to the publication of his book—"The Integrative Action of the Nervous System." This was an immediate classic. Sherrington's aim was to make the reactions of the spinal cord intelligible by analyzing them into their simplest components. To achieve simplicity the spinal cord had to be isolated from the brain which normally directs it. The spinal reflexes are therefore the reactions of a mutilated fragment of the nervous system and they are produced in a thoroughly artificial setting. But Sherrington's study of them showed first that in these simplified conditions they could be produced with mechanical regularity, and second that these simple reactions could be combined together so as to build up much more elaborate patterns of activity. After this work it seemed much more reasonable to speak of the mechanism of the spinal reflexes and to suppose that more complex behavior might come of their integration. It is true that nowadays the fashion is to decry this kind of analysis and to maintain that the organism can only be considered as a whole. We may have reached that stage, but we have learned a great deal from the analysis none the less. Sherrington himself was content with the activities which do not involve the cerebrum and would always be classed as reflex in spite of their complication, adjustments of posture and locomotion for instance. The cerebrum seemed to him to introduce quite a different order of complexity; and it was Pavlov who developed the idea of a truly mechanical brain—with the warning that we can not expect to understand the mechanism which underlies behavior if we speak or think of it in terms which imply the mind.

Pavlov's teaching, like Freud's, has been publicized too much and has suffered from it. It has left an enduring mark on neurology but much more as the basis of a particular technique of research than as the basis of a philosophy. For in the present period new information about the working of the brain has been accumulating at such a rate that the theories are scarcely worth making. As usual in physiology the

new information has come as the result of technical improvements in other fields, in brain surgery, in experimental psychology and particularly in the detection of small electric currents. I can only deal with a few lines of work which will show how things are developing. They may well make a familiar story to you since it is in the United States that much of the development has taken place, but it is this continued, rapid advance which is my main theme.

First of all we have had far more detailed studies of the mechanism of reflexes. Sherrington stimulated nerves and recorded the reflex contractions of individual muscles. In this way he could tell how faithfully the signals coming out of the cord to the muscles copied those which he had sent into it—whether the reflex pathway had inertia or was dead beat and what sort of changes occurred in it. But nowadays the signals which enter and leave the cord can be split up into the individual nerve impulses of which they are composed. These are recorded electrically and their appearance can be timed with an immensely greater accuracy. Recording the electric changes which accompany nervous activity is an old story: it was used by Gotch and Victor Horsley 50 years ago to trace the pathways of conduction from the brain to the cord, but the modern development, started by the work of Gasser and Erlanger at St. Louis, has now reached such precision that we can make a time table accurate to a ten thousandth of a second for each pulse of activity. And with micro-electrodes the search can be carried deep into the cell masses of the gray matter. But the outcome is still the same. When the conditions are standardized we find an exact precision of response within the central nervous system, a mechanical regularity extending to the units as well as to the summed effect of the whole mass of nerve cells and fibers. There is much more to be done, but so far there has been no hint of any processes outside the range of a mathematical universe.

But very naturally the reactions which are submitted to this kind of minute analysis are not a random sample. They are selected just because there is some chance that the analysis can be made, and nearly all of them have been reactions of the local executive parts of the nervous system, the spinal cord and the brain stem. If these parts are not directed by the brain the animal does act—or react—as if it were an automaton, with a mechanical regularity which allows us to predict exactly what it will do in the circumstances. In the intact animal there is the same local mechanism of nerve cells and fibers in the cord but it is made use of by the brain to bring about an entirely different sort of behavior—one which seems far less automatic. A brainless cat will lift its foot each time the skin is pinched, but a normal cat may do almost anything and will probably do something different each time. Evidently when the brain is in control the connection between incoming and outgoing signals is far more obscure.

Here we are still on the outskirts. A great deal is known about the nervous pathways in the brain and about the sort of activity which takes place in the nerve cells, but it does not get us very far. We are dealing with what seems to be no more than a great sheet of nerve cells linked by nerve fibers to some central cell masses and to the rest of the nervous system. We can be fairly certain, too, that its working must depend on the spatial distribution of activity in it. This is determined by the particular pathways which must be taken by the incoming and outgoing messages, for the messages are all in the same form wherever they come from and it is because they arrive in different regions that we interpret one as sight and another as sound. Thus if we look at a bright cross the initial event in the brain will be the development of cellular activity (which we can record electrically) in a more or less cross-shaped area at the back of the occipital lobe, and if we listen to a voice the same kind of activity will appear in the temporal lobe with a pattern, in space and time, corresponding to the areas of vibration in the cochlea. Probably each smell will influence the olfactory area in a similar way—we do not yet know enough to say what sort of shapes will correspond to—say—the smell of a violet or of an onion, but we can be fairly certain that all these different pictures—of visual, auditory, olfactory and tactile stimuli—are made up of the same elements, rapid sequences of nerve impulses distributed more or less thickly over the receiving areas and calling up more or less activity in the nerve cells there.

The detailed mapping of the patterns formed in the brain by the sense organs—the patterns which mirror the external world—is an achievement of the last few years and much of it has been done not 100 miles from where we are now. But it tells us only about the way in which information is sent into the brain and not about the way in which the brain reacts to it. In fact, the mapping has to be done in a brain which is anesthetized so that the sensory picture can stand out against a quiet background. Otherwise there would be a constantly changing activity to confuse the map. It is this activity, in all parts of the brain, which should tell us how the sensory pictures are recognized and used to guide our behavior, but to analyze it we need to know what is going on in the brain of a conscious subject. The arrival of a sensory message in the anesthetized brain is like the ringing of a telephone bell in a house where all the inmates are asleep. Naturally we should like to go on with the story, to find out what happens when the

nerve-cells are awake and can attend to the message, how they recognize the author of it and decide on the answer they shall give. In fact, we want to know what happens in the normal unanesthetized brain when a familiar sensory picture appears and calls up associations and movements.

Here there are only some odd scraps of information. The difficulties seem to be mainly technical. As far as we can tell any change in nerve cell activity should produce a corresponding change in the electric currents in the surrounding medium, and if we could record at will from any group of nerve cells in the brain we should be in a fair way to knowing what happens when a new sensory picture is thrown on the cortical surface. But in a man with an intact skull we can not place electrodes in immediate contact with the brain and so we can only record the average of all the electric changes over a fairly large area—the average activity of several million nerve cells and not the exact events in each. It is remarkable that such an average should give anything that can be recorded, but that it does so was shown 15 years ago by Hans Berger. Berger found that in a subject at rest and with eyes closed a regular series of potential waves could be detected by electrodes on the head. These come from the cerebral cortex and indicate an activity in the nerve cells over a fairly large area. But unfortunately Berger's α rhythm seems to be some sort of basic activity of the undisturbed brain. It has a fixed frequency (8–10 a second) and disappears as soon as visual attention is aroused. Thus the α waves can not tell us much about the specific activities by which the brain patterns are analyzed. One thing they can do, however, is to show something of the nervous processes which underlie a shift of attention from one field to another. In man, for instance, where vision is the predominant sense, the rhythm comes and goes whenever the attention is transferred from the visual field to the auditory and *vice versa*. From the size and distribution of the waves, therefore, we can form some idea of the extent of the brain surface which may be normally involved in vision and hearing.

The α waves show us no more than the basic rhythm of those parts of the brain which are awake but have little to do. But there is a further development which tells us something about the specific activities of the visual regions. It depends on forcing the nerve cells to work in unison by illuminating the field with a flickering light. When this is done the potential changes over the occipital region have a frequency corresponding to that of the flicker and are large enough to record through the skull. We have therefore what amounts to a method of tracing the visual signals in the brain, for we can make them fairly easy to recognize as long as the time sequence is preserved.

I will not trouble you with all the details of these flicker rhythms except to say that they seem to reveal an interesting borderland between the primary visual area and the rest of the brain. In this borderland (which extends well beyond the boundaries of the occipital lobe) the spatial as well as the temporal pattern of the excitation is preserved to some extent, but the spread of the visual signals into it is governed partly by the degree of attention given to the visual field, for the diversion of attention to another task will often disorganize the rhythm. And there are all sorts of interactions between the flicker rhythm and the α rhythm, which tends to reassert itself when attention weakens, and may combine with the flicker rhythm, if the two frequencies are suitably related, or may supplant it altogether.

Another point about the activity in this borderland area is that it is far from being an exact copy of the patterns of light and shade which fall on the retina. There is evidence of a good deal of interaction, not only between different points on the same side of the brain but between the two sides. For instance, if we look at a field of which only the right or the left half is flickering, the flicker potentials will appear on the opposite side of the head—this is where the signals of the flicker would arrive. But if the two halves of the field are made to flicker at different rates, my own brain, at any rate, gives up the unequal struggle and produces a confused medley of frequencies much the same on both sides.

In interpreting results of this sort it is very easy to be misled, for it is a long way from a flickering screen to the occipital lobes and a still longer way from there to the mind. The flicker waves do seem to be somewhere on the direct route, however, for when they change in rate or regularity there is usually a change in the sensation which has the same direction, faster or slower, though we may not be able to analyze it more precisely. Unfortunately with present techniques the method can only be applied to visual events. A repeated noise like that of a machine gun does not give a corresponding series of potential waves large enough to detect through the skull—either because they are not developed over a large enough area or because the area is unfavorably placed. I am afraid, therefore, that the present technique of recording brain events, by oscillographs connected with electrodes on the head, is not likely to lead very far. But such a technique may soon be superseded; judged by the standards of modern physics it is already obsolete, and I think we should look forward to the possibility of being able to record all the electrical events—the changing potentials and ionic move-

ments—within the brain in far greater detail and without hindrance from the skull.

What can we expect if such a development occurs, as I think it is bound to do sooner or later?—when we can study the whole changing pattern of activity in the cerebral hemispheres from moment to moment?

It will not necessarily tell us much about a most important and characteristic property of the brain, its power of learning, of forming associations or conditioned reflexes, for this must depend on changes which are persistent and may not give rise to electrical effects. In fact, it may need a biochemical and histological survey to show us why the dog comes to salivate whenever the dinner bell is rung. But an electrical survey could scarcely avoid giving some entirely novel information about what is happening in the brain when we think or solve problems or decide what to do. The progress of neurology has been full of surprises and it will not do to predict: but sooner or later we are likely to reach a position where some very fundamental problems ought to arise. For example, in the brain of a conscious man will there be the same mechanical precision in the response of nerve cells and cell masses to the signals which reach them? Isaac Newton in one of his few excursions into neurology remarks that "the soul may determine the passage of animal spirits into this or that nerve and so may cause all the motions we see in animals." Is there any chance that we shall reach a position where such a possibility might be put to experimental test?

I have the feeling that we shall always find a catch somewhere, as I suppose the alchemists always did when it came to the final moment of projection. The problem may become more and more meaningless as we seem to come nearer to it, or perhaps it will become obvious that it is not one which could ever be solved by beings like ourselves. However, this really does not matter, for we can be quite certain of one thing: whatever the final outcome of inquiries about the mechanism of the brain there is an immense amount waiting to be found out on the way. It is almost within our grasp even now. Before the war the younger generation of neurophysiologists were advancing at a pace which accelerated every year, and those of us who dated back to the string galvanometer were already out of breath. When they come back again we may confidently expect to be left so far behind that these philosophic speculations will be our only consolation. The alchemists may have wasted their time in futile attempts to reach a goal which was not there, but they turned into chemists soon enough. In the same way the search for the mechanisms of the brain, though its goal, as we see it now, is perhaps unattainable, may lead us to a new understanding of human behavior—a synthesis of physiology and psychology. And with that in mind we can end with another quotation from Newton—which sums up what I have tried to say:

> As in mathematics so in natural philosophy the investigation of difficult things by the method of analysis ought ever to proceed the method of composition; and if natural philosophy in all its parts by pursuing this method shall at length be perfected, the bonds of moral philosophy will also be enlarged.

OBITUARY

FRANCIS PERRY DUNNINGTON
1851–1944

Francis Perry Dunnington was born in Baltimore on March 3, 1851. At the age of sixteen he entered the University of Virgina, where he remained until called by death on February 3, 1944, just one month before his 93rd birthday. He graduated with the B.S. degree in 1871 and the following year received the degrees of C.E. and M.E. In the same year he was made adjunct professor of analytical chemistry and was promoted to a full professorship in 1884. From 1908 to 1919 he was professor of analytical and industrial chemistry, after which he retired from active teaching. He was a fellow of the American Association for the Advancement of Science and held membership in the American Chemical Society, the British Association for the Advancement of Science, the Chemical Society (London), American Electrochemical Society, the Franklin Institute and Phi Beta Kappa. When the first edition of "American Men of Science" appeared in 1906, a star was prefixed to the word *Chemistry* following Professor Dunnington's name, which means that he was ranked among the leading thousand scientists in the United States and one of the 175 American chemists whose work at that time was considered to be the most important.

Professor Dunnington's early training in chemistry was under that most able teacher and great chemist, John W. Mallet. He was associated with Dr. Mallet until the latter's retirement in 1908.

When Professor Dunnington graduated in the early seventies, the demand for chemists in industry was small and so he embarked on a career of teaching and investigation. He became recognized as one of the outstanding analytical chemists of his time. His publications number 68, many of them being joint reports on work with his students. Perhaps his greatest contribution to science was the discovery of the extensive

occurrence of titanium in American soil and rocks. While he never engaged in industrial activities, his influence in this field was far-reaching and it must have been a source of great satisfaction to him to know that many of his students have contributed in a large measure to the development of American industries. His former students include many well-known chemists and engineers.

The Charles Herty Medal was awarded Professor Dunnington in 1935 by the Georgia State College for Women at Milledgeville, Ga., "for excellent service in the field of chemistry in the South . . . and especially for his splendid record as a teacher of chemists who have attained renown." The late Dr. Charles L. Reese, for many years chemical director at E. I. du Pont de Nemours and Company, and an old student of Professor Dunnington, has written affectionately of him in *Industrial and Engineering Chemistry* (22: 1408, 1930), under the caption "American Contemporaries." Here are mentioned many of his most prominent students. Dr. Reese's description of Professor Dunnington and a personal incident during his student days at the university are well worth quoting.

> Tall, red-headed (but lacking the fiery disposition usually accompanying this characteristic), a gentle, kindly face—Dr. Dunnington presented an imposing personality. In addition to having the faculty of thoroughly imparting knowledge, he took a real personal interest in his students even to the extent of caring for them when they became ill. I recall vividly an instance in my own case when I was a student at Virginia. I had been suffering from an ailment and Dr. Dunnington one day noticed my apparent indisposition. He promptly sent me to his own home, where his kind hospitality and watchful care were extended to me until I was restored to normal health. Thus, his home came to be regarded by his students as a sort of haven to which they could go in times of distress, whether physical, mental or spiritual. The very atmosphere of his home, made more charming by the presence of his lovely wife and children, was an inspiration. He was imbued with a radiating spirit of brotherly love that endeared him to his associates, and outside of his duties of teaching chemistry ''he went about doing good.''

Professor Dunnington's activities were not confined to university duties. He always took an active interest in the welfare of the community. The installation of a modern sewage system for more than a hundred buildings in the university area was due to his efforts and personal supervision. This and many other local civic improvements are the result of his efforts. For many years he was an elder in the Presbyterian Church in Charlottesville and he was an ardent supporter of the cause of temperance. After his retirement from teaching in 1919, he devoted himself to a number of activities, much time being spent cataloguing the chemical museum of the Cobb Chemical Laboratory, working on the solubility of borates and writing several philosophical articles from a religious standpoint. Until recent years when his health began to fail, Professor Dunnington spent many pleasant hours working in his garden and each fall would gather baskets of apples and pears which he enjoyed giving to friends.

Francis Perry Dunnington, known affectionately by his former students and friends as "Old Dunny," will long be remembered as an exceptional teacher—patient, thorough, kind-hearted and fair. He emphasized the importance of being able to do a job with the materials and apparatus at hand, and by his own ingenuity in this respect he developed this worthwhile trait in his students. In his passing, the University of Virginia and the city of Charlottesville, where he lived and labored for more than three quarters of a century, have lost one of their great personalities. He was a scholar, a scientist, a teacher and a Christian gentleman of the Old South.

JOHN H. YOE

RECENT DEATHS

DR. JAMES CONNER ATTIX, since 1904 until his retirement in 1943 professor of chemistry and toxicology at Temple University, Philadelphia, died on April 20 at the age of seventy-four years.

FRANKLIN B. HANLEY, instructor in geology at the University of Minnesota, died on April 24 at the age of forty-five years. Mr. Hanley had been on leave from the university since June, 1942, to serve as executive secretary at the Naval Radio and Sound Laboratory at San Diego, Calif.

CHARLES E. HELLMAYR, associate curator of birds of the Chicago Natural History Museum, has died in Switzerland at the age of sixty-six years. He was the principal author of "The Birds of the Americas."

DR. JAMES CRAWFORD SIMPSON, who retired in 1941 as professor of histology and embryology and dean of the faculty of medicine of McGill University, died on April 20 in his sixty-eighth year.

SCIENTIFIC EVENTS

THE PROPOSED NATIONAL RESEARCH COUNCIL FOR INDIA

THE National Institution of Sciences of India, according to *Science and Culture*, Calcutta, has passed the following resolutions advocating the founding of a National Research Council.

(1) That it is necessary to establish at an early date a National Research Council of India under the statutory authority of the Government of India.

(2) The purpose of the National Research Council shall be:

(a) to plan and watch over the main lines of research and technical developments in accordance with national needs to see that the application of science to the public welfare is adjusted to some consistent plan, to advise the Government on a common policy and to insure that available resources for research and developments are distributed to the best advantage of the country;

(b) to advise and help relevant authorities and institutions regarding the training and supply of scientific personnel for pure and applied research, and

(c) to distribute grants for promoting approved researches, for the maintenance of selected research scholars, for scientific publication and other purposes.

The president of the National Research Council shall be a member of the viceroy's cabinet.

For the performance of its functions, the National Research Council shall, in consultation with non-official scientific organizations, universities and institutions of a university rank, scientific departments of the Government and federations of chambers of commerce, constitute the following boards of research, each of which will be responsible within its own particular sphere for giving effect to the policy of the National Research Council.

(1) Board of Scientific Research (mathematics, statistics, physics, chemistry, botany, zoology, geology, geography, psychology, etc.).

(2) Board of Agricultural Research (soils, crops, animal husbandry, fishery and forestry).

(3) Board of Medical and Public Health Research, including medical science.

(4) Board of Engineering Research, including mining, metallurgy and such other boards as may be considered to be necessary.

For the purpose of its work each board will be authorized to constitute research committees for all important subjects, to settle the objects of the research, indicate the individuals or organizations which could undertake the several component parts of the inquiry, receive and coordinate the information, make it available to those who will turn it to advantage to form a national plan into which all who are in position to contribute information can fit the particular lines on research. Governing bodies of the National Research Laboratories when established shall be constituted in consultation with the relevant research committees.

The National Research Council shall work in close cooperation with the development organizations in the country. To enable effect to be given to the policy of scientific development determined by the National Research Council the Government should make an annual grant of at least five crores of rupees.

THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

The seventy-fourth annual meeting of the Wisconsin Academy of Sciences, Arts and Letters was held on April 14 and 15 at the University of Wisconsin. Approximately a hundred members and guests gathered to hear the address delivered by the retiring president, Dr. A. W. Schorger, president of the Burgess Cellulose Company, Madison. The title of his address was "The Abundant Life." Dr. Leon J. Cole, professor of genetics at the university, showed colored motion pictures illustrating the life of the fur seals of the Pribilof Islands. Dr. Schorger was elected a life member of the academy.

The following officers were elected to serve in 1944:

President, Dr. H. A. Schuette, department of chemistry, University of Wisconsin.

Vice-president in Sciences, Ruth Walker, Milwaukee.

Vice-president in Arts, Walter Bubbert, Milwaukee.

Vice-president in Letters, Dr. Helen White, department of English, University of Wisconsin.

Secretary-Treasurer, Dr. Banner Bill Morgan, parasitologist, department of veterinary science, University of Wisconsin.

Librarian, Halvor O. Teisberg, University Library, University of Wisconsin.

Curator, Dr. Edward P. Alexander, superintendent of the Wisconsin State Historical Society, Madison.

Member, Committee on Publications, Dr. Philo M. Buck, Jr., professor of comparative literature, University of Wisconsin.

Members, Library Committee, Dr. O. L. Kowalke, professor of chemical engineering, University of Wisconsin; Professor Ruth Marshall, Wisconsin Dells; Dr. James F. Groves, department of biology, Ripon College; and Dr. W. N. Steil, Marquette University, Milwaukee.

Representative on the Council of the American Association for the Advancement of Science, Dr. Banner Bill Morgan.

Approximately twenty-four papers were presented at the regular sessions, including ornithology, botany, mammalogy, bacteriology, plant pathology, zoology, limnology, entomology, protozoology, chemistry, forest products, medicine, soils and agriculture.

Dr. Michael F. Guyer, professor of zoology at the university, presented a memorial tribute to the late Professor Chancey Juday, life member and past-president of the academy.

THE CHICAGO CONVENTION OF FOOD TECHNOLOGISTS

The fifth annual meeting of the Institute of Food Technologists will be held under the presidency of W. V. Cruess on May 29, 30 and 31 at the Edgewater Beach Hotel in Chicago. Major General S. G. Henry, director of New Developments Division, Office of Chief of Staff of the U. S. War Department, will deliver the keynote address on "The Food Technologist's Role in the War." George A. Sloan, president

of the Nutrition Foundation, Inc., of New York, will follow with an address entitled "The Role of Industry in Strengthening Fundamental Research."

Technical sessions are set for Monday afternoon and for Tuesday morning and afternoon. Roy C. Newton, of Swift & Company, Chicago, will discuss "The American Food Supply" at the luncheon on Tuesday, which will be presided over by M. L. Laing, of Armour and Company, chairman of the Chicago Section.

The annual banquet will be given on Tuesday evening when presentation will be made of the 1944 Nicholas Appert Medal Award, established in 1941 by the Chicago Section, to Dr. C. A. Browne, of the U. S. Department of Agriculture, "for outstanding contributions to food technology." Following the presentation, Dr. Browne will speak on "The Keeping Qualities of Sugars and Sugar-Containing Products During Storage." The banquet will be concluded with an address by William A. Patterson, president of the United Air Lines.

The last day of the convention will be devoted to a discussion of post-war problems relating to the food industry. Two general sessions and a luncheon program have been arranged. R. C. Newton will preside at the luncheon and Mr. Cruess will make an address entitled "Taking Stock and Looking Forward."

In the afternoon a forum on "Future Objectives and Planning of the Institute of Food Technologists" presided over by Professor Samuel C. Prescott, of the Massachusetts Institute of Technology, will be led by R. H. Lueck, director of research of the American Can Company, New York, and chairman of the objectives and planning committee of the institute.

An exposition will be held in connection with the meeting. Space for thirty displays has been assigned to industrial exhibitors. Educational booths will be maintained by the Chicago Section of the institute and the Quartermaster Corps Subsistence Laboratory.

THE STUDY AND TEACHING OF PHYSICAL THERAPY

THE sum of $1,100,000 has been provided by Bernard M. Baruch for a ten-year program in the study and teaching of physical therapy with special reference to the rehabilitation of wounded and ill men discharged from the Army. The funds are to be expended within the next ten years and will be distributed as follows:

Columbia University College of Physicians and Surgeons, $400,000.
New York University College of Medicine, $250,000.
Medical College of Virginia, $250,000.
Selected medical schools not yet announced, $100,000.
For fellowships and residencies, $100,000.

A committee of scientific and medical men, of which Dr. Ray Lyman Wilbur, chancellor of Stanford University, is chairman, has outlined the following plan to provide for the proper development of physical therapy: An adequate supply of physicians to teach the subject; the establishment of centers to promote scientific research on non-medical procedures, including claims that have been made by practitioners of osteopathy, chiropractic, etc.; proper usage of physical medicine in relation to war-time rehabilitation.

The grant will be administered by a board of three directed by Dr. Frank H. Krusen, professor of physical therapy at the University of Minnesota and head of the section on physical therapy of the Mayo Clinic. Dr. Wilbur will be chairman of the committee. The third member is Miss Mary Boyle, an assistant to Mr. Baruch for the last thirty-five years. Headquarters of the board will be at 597 Madison Avenue, New York City.

The grant to the College of Physicians and Surgeons of Columbia University provides for the establishment of a center for research and training, with particular reference to its application for returning veterans. New York University will establish a center for teaching and special research in the preventive and manipulative mechanics of physical medicine, and the Medical College of Virginia a center for teaching and research with particular reference to hydrology, climatology and spa therapy. The grant of $100,000 to selected medical schools is for the development of an immediate program for the physical rehabilitation of war casualties and those injured in industry. The fellowships or residencies will be for the benefit of qualified physicians who wish to receive special training in physical medicine.

The plan calls for the coordination of all work in physical therapy relating to the rehabilitation of war wounded. This will be done through the appointment by the administrative board of a special advisory committee and a second committee on war and post-war physical rehabilitation which will include representatives of the armed services, the Veterans Administration and other interested groups.

THE INSTITUTE OF BIOLOGY AND EXPERIMENTAL MEDICINE AT BUENOS AIRES

PROFESSOR BERNARDO A. HOUSSAY, the eminent Argentine physiologist whose dismissal from his professorship in the University of Buenos Aires has been discussed in recent issues of SCIENCE (98: 467, 1943; 99: 166, 176, 1944), has informed friends in this country that he has organized with private support a modest laboratory called "Instituto de Biología y Medicina Experimental," at Calle Costa Rica 4185, Buenos Aires. Associated with Professor Houssay will be Drs. E. Braun Menendez and V. G. Foglia,

who were members of his staff in the university; Juan T. Lewis, formerly professor of physiology at Rosario, and Oscar Orías, who was professor of physiology at Córdoba. As recently announced, the Rockefeller Foundation has made a grant for equipment and supplies and for stipends to several young investigators who wish to work with the group.

Because the library accumulated by Dr. Houssay through years of effort and personal expense had been given by him to the University of Buenos Aires before his separation from its faculty, the new institute is in need of reprints and other scientific literature. North American colleagues can give practical evidence of sympathy and good will for the new institution and its devoted members by sending their publications.

Referring in a recent letter to the dismissal inflicted upon him and his colleagues by the government because they signed a manifesto advocating Argentine participation in a Pan-American democratic policy, Dr. Houssay writes (translation): "All that remains to us is life, honor and dignity, the scientific vocation and love of our distracted country."

SCIENTIFIC NOTES AND NEWS

Sir Richard Gregory received from the council of the British Association on his eightieth birthday a message of good wishes expressing appreciation of his service to the association.

The Luther Gulick Award for distinguished service in physical education was presented on April 24 at the convention in New York City of the American Association for Health, Physical Education and Recreation to Dr. C. H. McCloy, research professor of anthropometry and physical education at the State University of Iowa. Dr. McCloy has been serving since January as civilian consultant to the Surgeon General of the U. S. Army. He is expected to return to the university in June.

The annual journal award of the Motion Picture Engineers Society was presented at the recent New York meeting to William L. Bell and Ray R. Scoville, of the Bell Telephone Laboratories, for their article describing the design and use of equipment for reducing background noise in film sound-recording systems.

Professor B. J. Lambert, head of the department of civil engineering at the State University of Iowa, is retiring after having been connected with the university for forty-two years. A formal dinner was held on April 25, to celebrate his seventieth birthday and to announce a scholarship fund set up in his honor. He received a scroll, bearing the names of contributors to the fund, expressing appreciation of his services to the university.

Bayard Long, since 1914 curator of the herbarium of the Philadelphia Botanical Club, research associate of botany at the Academy of Natural Sciences of Philadelphia, was presented with a gift of books and a purse at the March meeting of the club. The presentation was made by the president of the club, Dr. Francis W. Pennell, curator of plants of the academy.

Dr. Angus E. Taylor, assistant professor of mathematics at the University of California at Los Angeles, has been elected a corresponding member of the National Academy of Exact, Physical and Natural Sciences of Lima, Peru.

The newly elected officers for the year 1944 for the Eastern Missouri Branch of the Society of American Bacteriologists are: *President,* Dr. John B. Rehm, Anheuser Busch, Inc., St. Louis; *Vice-president,* Dr. Fred W. Gallagher, department of bacteriology, St. Louis University School of Medicine; *Secretary-Treasurer,* Mary Louise Hoevel, St. Louis County Hospital, Clayton, and *Counsellor,* Dr. Philip L. Varney, department of bacteriology of the School of Medicine of Washington University.

At a meeting on April 11 of the Wellesley College Chapter of the Society of Sigma Xi, Dr. Louise S. McDowell, professor of physics, was elected president, and Dr. Elizabeth Eiselin, instructor in geology, was elected vice-president. At this meeting, Dr. Hugh M. Raup, assistant professor of plant ecology at the Arnold Arboretum of Harvard University, gave the annual lecture. It was entitled "Botanical Exploration along the Alaska Highway."

At the sixty-sixth annual general meeting of the Royal Institute of Chemistry held on March 15, Professor Alexander Findlay, professor of chemistry at the University of Aberdeen, was reelected to the presidency. He made the formal announcement that the style "Royal" had been added to the title of the institute. At this meeting the Sir Edward Frankland Medal and Prize for registered students of the institute was awarded to Dudley Rhoden Scarffe, of the Imperial College of Science and Technology, for his essay entitled "Introduction of the Chemist to the Public."

Dr. R. G. W. Norrish, F.R.S., professor of physical chemistry at the University of Cambridge, has been elected president of the British Association of Chemists.

Dr. Hugh Stott Taylor, David B. Jones professor of physical chemistry, will succeed in July, 1945, Dr. Luther P. Eisenhart as dean of the Graduate School

of Princeton University. The change, which would normally have taken place this June, has been postponed owing to the war duties of both.

COMMANDER ARTHUR S. ADAMS, U.S.N. (retired), assistant dean of the College of Engineering of Cornell University, on completion of his work with the Navy will become provost of the university.

PROFESSOR HARRY B. VAN DYKE, director of the division of pharmacology of the Squibb Institute of Medical Research, has been appointed professor of pharmacology and head of the department of Columbia University. Dr. Paul F. Kerr, professor of mineralogy, has been named executive officer of the department of geology.

DR. F. A. E. CREW, F.R.S., since 1938 Buchanan professor of animal genetics at the University of Edinburgh, has been appointed to succeed Professor P. S. Lelean as Bruce and John Usher professor of public health. Dr. Crew has had leave of absence for two years to work as director of biological research with the rank of brigadier in the medical department of the British War Office.

AT the February meeting of the Medical Fellowship Board of the National Research Council, Washington, D. C., of which Dr. Francis G. Blake, Sterling professor of medicine at Yale University, is chairman, two fellowships in the medical sciences were awarded. Three appointments, including two renewals, were made to fellowships in the filtrable viruses and orthopedic surgery. These are as follows: *Medical Sciences,* Sidney S. Sobin, Harvard Medical School, and Harry A. Wilmer, the Johns Hopkins University; *Filtrable Viruses,* Edward H. Anderson (renewal), Vanderbilt University, and I. William McLean, Jr. (renewal), Duke Hospital; *Orthopedic Surgery,* Paul S. Rubin, the Johns Hopkins University.

DR. WILBUR A. SAWYER, director of the International Health Division of the Rockefeller Foundation, has been appointed director of the Health Division of the United Nations Relief and Rehabilitation Administration.

DR. LESLIE EARLE ARNOW, head of the department of biochemical research in the division of medical research of Sharp and Dohme, Glenolden, Pa., has been appointed director of research.

F. H. FRANKLAND, since 1934 director of engineering for the American Institute of Steel Construction, has retired in order to undertake private practice as a consulting engineer.

THOMAS R. CAMP, since 1929 associate professor of sanitary engineering at the Massachusetts Institute of Technology, has resigned to open offices in the Statler Office Building, Boston, for full-time practice as a consulting engineer. He will specialize in water works, sewage works, municipal and industrial wastes, stream sanitation and flood control.

DR. ROBERT RAE, professor of agriculture at the University of Reading, England, and a member of the board of the National Institute of Research in Dairying, will succeed Professor James A. Scott Watson, who for the past two years has been agricultural attaché at the British Embassy in Washington and agricultural adviser to the High Commissioner for the United Kingdom in Canada.

DR. GEORGE K. K. LINK, professor of plant pathology at the University of Chicago, was given leave of absence for the winter quarter and is in residence at the University of Arizona, where he has guest privileges in the department of botany and the department of plant pathology. During February and March he lectured at the University of Southern California, at the University of Arizona at the Citrus Experiment Station at Riverside, at the California Institute of Technology, at Stanford University and at the University of California at Berkeley.

DR. ARTHUR MASSEY, medical officer of health of Coventry, England, has arrived in the United States as a guest of the American Public Health Association. Under the auspices of the British Information Services he will attend a series of state and regional public health meetings in the central and western states during May and June, together with a group of speakers organized to give refresher courses for two-day periods. Dr. Massey, with ten other members of the group, will appear before public health associations in Des Moines, Iowa; Minneapolis, Minn.; Chicago, Ill.; Madison, Wis.; Fargo, N. D.; Helena, Mont.; Spokane, Wash.; Moscow, Idaho; Portland, Ore.; Sacramento, Calif.; Pasadena, Calif.; Salt Lake City, Utah; Denver, Colo., and Raton, N. M., and before the health officers and public health nurses of New York State at Saratoga.

JOSEPH W. BARKER, professor of electrical engineering and dean of the faculty of engineering of Columbia University, will be the principal speaker at the ninety-fourth annual commencement on May 14 of the University of Rochester. Dean Barker has had leave of absence since 1941 to become special assistant to the U. S. Assistant Secretary of the Navy.

DR. HOWARD T. KARSNER, professor of pathology and director of the Institute of Pathology of Western Reserve University and of the University Hospitals of Cleveland, will give on May 12 at the Long Island College of Medicine, Brooklyn, N. Y., the Adam M. Miller Memorial Lecture. His subject will be the "Calcific Aortic Stenosis."

Dr. Thomas Grier Miller, professor of clinical medicine at the School of Medicine of the University of Pennsylvania, will deliver on May 26 the twentieth Lewis Linn McArthur Lecture of the Frank Billings Foundation at the Institute of Medicine of Chicago. The subject of the lecture will be "Observations on the Human Digestive Tract by Intubation."

The James Arthur Lecture on the Evolution of the Human Brain of the American Museum of Natural History will be given on May 11, at 8:15 P.M. by Professor James Howard McGregor, professor emeritus of zoology of Columbia University and research associate of the museum. His subject will be "The Brains of Primates."

An Associated Press dispatch reports that Lieutenant Commander J. W. S. Marr and a party of fourteen British scientific men are now in the Antarctic making a study of polar meteorology, radio conditions and mineral resources. The party established a base in February at Hope Bay, Grahamland, and will remain there for two years.

The twentieth annual conference and exhibit of the National Safety Council was held in Pittsburgh on April 25, 26 and 27.

A Conference on Convalescence and Rehabilitation, with Dr. Oswald R. Jones as chairman, arranged by the Committee on Public Health Relations with the aid of a grant from the Josiah Macy Jr. Foundation, was held at the New York Academy of Medicine on April 25 and 26.

The second annual meeting of the Conference on the Scientific Spirit and Democratic Faith, of which Dr. John Dewey is honorary chairman, will be held on May 27 and 28 at 2 West 64th Street, New York City.

The National Committee for Mental Hygiene has established a fund for research in psychosomatic medicine dealing with the relationship between the emotions and bodily illness. The fund begins with a nucleus of $10,000, which, it is expected, will be increased later in the light of developments and results. Dr. George S. Stevenson is the medical director of the committee under which the fund will be administered. Dr. Edward Weiss, professor of clinical medicine at the School of Medicine of Temple University, Philadelphia, has been appointed director of the fund. Members of the committee to select projects have been elected as follows: Dr. Charles M. Aldrich, head of the department of pediatric research of the Mayo Clinic, Rochester, Minn.; Dr. Franz Alexander, director of the Institute of Psychoanalysis, Chicago; Dr. Stanley Cobb, professor of neuropathology at the Harvard Medical School; Lieutenant Colonel William Menninger, head of the psychiatric division of the U. S. Army, Medical Department, Surgeon General's Office, Washington, D. C., and Dr. John Romano, professor of psychiatry at the Medical School of the University of Cincinnati.

It is reported in the daily press that Dr. Albert Ashton Berg, consulting surgeon of Mt. Sinai Hospital, New York City, president-elect of the International College of Surgeons, has given the hospital a sum of money for a modern research laboratory to be constructed after the war. The amount of the gift has not been announced, but plans for the building, to be known as the Henry W. Berg Research Laboratory, it is said, provide accommodations for research in bacteriology, pathology, physiology, chemistry, gastro-enterology, cardiology and other subjects.

The following chemicals are wanted by the National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, Ill.: Guanine, adenine, thymine and cytosine desoxyribosides; thymine and cytosine desoxyriboside phosphoric esters; optical fluorite—transmission limit 144 A°; sphacelenic acid; thiol carbamic acid ethyl ester (thiourethane) 10 g; thione carbamic acid ethyl ester (xanthogenamide) 10 g; dithio urethane 10 g; 1-benzyl or 1-phenyl cyclopentan-1-ol; 1-benzyl or 1-phenyl cyclopentan-1,2-diol; 1-benzyl or 1-phenyl cyclopentene-1; triamino triethyl amine β, β′-dipyridyl; sym bis acetyl acetone; triiodo acetic acid (100 grams), and isatin beta oxime.

The Royal Aeronautical Society, London, has recently received from an anonymous donor a collection of aeronautical medals, more than three hundred in number, dating from 1714 to 1941.

The report on "Industry and Research" of the Federation of British Industries has recommended the establishment of an organization whose principal object would be to stress continuously the need for industrial research and to promote and foster it in all possible ways. The form and functions of this suggested organization were discussed at a recent conference which was attended by representatives of the Royal Society, the Department of Scientific and Industrial Research, the universities and the research associations. A full discussion took place, and a subcommittee was appointed to inquire further into the subject.

The Nuffield Foundation Trustees, in development of one of the objects specified by Lord Nuffield, are undertaking a survey of the problems of aging and the care of old people. The British Ministry of Health and the Assistance Board have warmly welcomed the proposal, and will cooperate in the conduct of the survey, the object of which is to collect and collate as much information as possible with regard to the problems, individual, social and medical, associated

with aging and old age; the work being done by public authorities and voluntary organizations, and the public and private resources that exist for the care and comfort of old people in Great Britain; the provision made for old people in those countries which have given special consideration to these problems; medical research on the causes and results of aging, and on the lines on which action might usefully be taken in the future by public authorities and private organizations, including the foundation. The chairman of the survey committee is Dr. B. Seebohm Rowntree, chairman of Rowntree and Company.

DISCUSSION

IS BIOLOGY A SCIENCE?

In "Life: Outlines of General Biology" Sir J. Arthur Thomson and Patrick Geddes say: "It is a regrettable fact that there is relatively little education in biology in the universities of the British Empire! There is abundance of first-class zoology and first-class botany, but there is relatively little general biology. No one can seriously pretend that a little zoology plus a little botany make a course of biology. One might as well say that a whiff of oxygen and a whiff of hydrogen will serve as a drink of water." These authors then tell of a student guide who was asked by a visiting professor the meaning of the word "biology" which he saw engraved over a door. After a bewildered pause the student replied: "Oh, yes! I remember now; biology is the dogfish and the bean plant."

Unfortunately general biology often is "the dogfish and the bean plant" or some other set of extractions from the biological sciences. Sometimes it is a little botany, a little zoology, a little physiology, a little anatomy, a little embryology, a little taxonomy, a little genetics, a little ecology, a little everything—a parade of discrete biological topics. If one may judge the biology course from some text-books it is an encyclopedia of biological terms, concepts and principles, which might be more conveniently arranged in alphabetical order.

Perhaps Dr. C. A. Shull, in approving of Report No. 15 of the U. S. Office of Education (SCIENCE, March 10) has been misled by courses and texts that are biology only in name. It is my opinion that Dr. Shull's anathema will not deter teachers of introductory and general courses in the biological sciences from continuing their efforts to develop biology courses which give promise of showing that biology is a science. After all, a science is a man-made category rather than an immutable compartment of knowledge imposed from above. Any science or subdivision thereof is an isolate from the totality of scientific knowledge. Under certain circumstances and for certain ends it may be convenient and appropriate to deal with a very restricted field of knowledge which can be fully and intensively explored by a specialist.

The old field of natural science has been subdivided into finer and finer categories as each former subdivision becomes too unwieldy to comprehend intensively. With no intention of decrying this tendency, which has been necessary to the expansion of knowledge and without which our conquest of the unknown would be impossible, I wish to suggest that other circumstances and other purposes demand broader and less penetrating viewpoints. I refer to present circumstances and to the purposes of general education. The present circumstances are the conditions of the democratic society in which we live and which we hope to improve; chief among the purposes of general education, I believe, is the preparation of an intelligent citizenry for the responsibilities of citizenship in our democracy. In this preparation the biological sciences must be recognized as essential to the understanding of the responsibilities, both personal and social, of the citizen. Good health, adequate growth and development, nutrition, food production, reproduction, heredity and environment, and the conservation of natural resources for use and for recreation are some of the topics appropriate to general education. These are biological rather than zoological or botanical topics, for they require fundamental knowledge drawn from both plant and animal kingdoms.

The more specialized a course is, the more difficult it becomes to select facts and principles which are most pertinent to the objectives of general education and to eliminate those of academic interest and those which have exaggerated significance in the minds of specialists who are unable to appreciate other objectives than their own. Biology, because it is more generalized than botany and zoology, thus lends itself better to general education than these specialized courses.

Furthermore, from a pedagogical standpoint, there is much to be gained in understanding and appreciation by the student if the living world is synthetically rather than analytically treated. Through common physiological phenomena and especially through ecological connections plants and animals, not excluding man, are bound in one great unit. Animals can not be thoroughly understood or appreciated without knowledge of plants; neither can plants be isolated from animals without losing much that is essential to a knowledge of their place in the world of man.

Because most of us have been trained as specialists it is easy for us to lose sight of the broader aspects of

the living world. Because biological knowledge was delivered to us in tight compartments, it is very difficult to reconstruct a unified science of biology. But such a science is possible and such a science, perhaps far from the perfection we desire, is being taught by many former zoologists and botanists who are becoming biologists. The process is not easy. It requires a thorough reeducation of the teacher. It may require new knowledge from unfamiliar fields; it demands a reassessment of values appropriate to new objectives; it means the discarding of some cherished "fundamentals" and the adoption of new ones; it may call for a rearrangement of topics and materials; and it may well suggest the exploration of new methods and techniques.

Admitting that some of the courses in general biology have been, as Dr. Shull declares, "a fraud against the student" and that many are not well unified, which are criticisms that might reasonably be directed towards other subjects, I am not ready to accept the dictum of Dr. Shull that biology is non-existent nor the pronouncements of others with whom biology is in disfavor. I think it will be found that courses in botany and zoology, on which Dr. Shull places his *nihil obstat*, are frequently no more unified than the worst of the biology courses.

It is true that the "existence of the word 'biology' does not mean that there is a well-unified science which can be so designated," but my own experience and that of others leave me with a strong conviction that much progress has been made towards unification and that " a better day will dawn" for the teaching of biological science as a result of the continued efforts of the general biologists to construct a unified course in biology.

As scientists, however, we should not be content to judge the merits of biology solely on the basis of opinions, pro and con. The opposing groups may have quite different objectives in mind, and we must first decide what we expect to accomplish by teaching the biological sciences. What I have in mind may differ from the ideas of other proponents of general biology. Even if we can agree on general objectives, it should be patent that subjective opinion for or against biology is not a sound basis for a final decision. Both hypotheses can and must be tested by properly planned and conducted educational experimentation before we can know whether we are accomplishing what we desire.

If I may be permitted to add a personal note, I should like to explain that I embarked unwillingly on the teaching of biology with ideas that were quite in agreement with those of Dr. Shull. In spite of early antagonisms which had been strongly conditioned as a result of my own specialized training, I have come to an entirely opposite opinion and a firm conviction that general biology courses merit the continued support of their adherents and greater tolerance on the part of those who oppose them.

LELAND H. TAYLOR

WEST VIRGINIA UNIVERSITY

"HORSE SERUM" A COMPOUND WORD

THE discussion of "horse serum" has already reached considerable length, but it may be permissible to make one more point—namely, that every one concerned has misinterpreted the nature of the disputed phrase. It is not a case of one noun being used as an adjective to modify another; it is a compound noun, exactly analogous to such Greek compounds as thermometer. The first member takes the place, not of an adjective, but of a phrase. "Horse serum" is serum from a horse; "fence post" is post of a fence; "rat poison" is poison for rats. Thermometer, if its first member were adjectival, would mean a "hot meter," not a measure of heat. In most such cases, the compound has a special and definite meaning, not conveyed by an adjective and noun. Had this been understood, neither the original editorial faux pas nor the resultant burst of argument need have occurred. The author (or, if he forgot it, the editor) would merely have inserted a hyphen between "horse" and "serum" and all would have been well.

That the situation was not understood is partly because, though the use of compounds in place of prepositional or other phrases in English has increased in recent years by leaps and bounds, we have not yet developed a consistent or in any way adequate orthography for indicating them. This is admirably illustrated by the playful contributor who wrote "horse sense" and "horse-laugh" in the same sentence. The makers of the Century Dictionary perceived the usefulness of the hyphen as an indicator, but few have followed them. So long as we offend the verities by writing compounds as separate words—which they are not—we shall have confusion and wrangles like the present.

C. A. WEATHERBY

GRAY HERBARIUM,
HARVARD UNIVERSITY

CONCERNING THE RATE OF EVAPORATION OF WATER THROUGH ORIENTED MONOLAYERS ON WATER

I HAVE read with the greatest interest the monograph on "Surface Chemistry" just published by the American Association for the Advancement of Science. The excellent foreword by Dr. Moulton, emphasizing the importance of this new branch of science, reminded me of the man who, I think, can rightly be considered as the founder of this science, my old and

esteemed friend, Professor Henry Devaux, of Bordeaux (France), who was the first to demonstrate clearly the existence of monomolecular layers at the surface of water. Dr. Langmuir, in his fundamental paper,[1] gave him full credit for this pioneer work, and described his experiments as "beautiful in their simplicity."

Professor Devaux, who is very old now, was still working on monolayers, under particularly difficult conditions, when I left France in August, 1942.

I should also like to mention the fact that, to my knowledge, I published the first paper on the influence, on the rate of evaporation of water, of a monolayer of oriented molecules. This paper undoubtedly escaped the attention of Dr. Langmuir, as it was printed in the *Journal of Experimental Medicine*[2] under the misleading title, "Further evidence indicating the existence of a superficial polarized layer of molecules at certain dilutions" (solutions of serum).

I reported a definite slowing up of the rate of evaporation, but my method was crude in comparison with that employed by Drs. Langmuir and Schaefer.

P. LECOMTE DU NOUY

SCIENTIFIC BOOKS

BOTANICAL BOOKS

The Succulent Euphorbieae (*Southern Africa*). By ALAIN WHITE, R. ALLEN DYER and BOYD L. SLOANE. 2 vols. xv + 990 + 11 + 11 pp. 1,102 figs. + 25 plates. Pasadena, Calif.: Abbey Garden Press. 1941. $12.00.

EVERY scholar has a dream of books that he would like to write if the fates but smiled. The authors of "The Succulent Euphorbieae" may be congratulated, not merely on the broad vision of their undertaking, but also on the splendid way in which their dream has been realized.

In the introduction we are told that the family Euphorbiaceae includes more than 250 genera and 6,000 species; this family is divided into a number of tribes, of which the largest is the Euphorbieae, "and it is with a part of this tribe alone that the present book deals." The largest genus of the tribe by far is *Euphorbia,* and this, *Monadenium* and *Synadenium* are the three genera considered in the present work, which is restricted to "what may somewhat indefinitely be called the succulent Euphorbias of southern Africa."

The introduction is devoted partly to a discussion of the peculiar inflorescence of this group—the cyathium—and to a consideration of the pistillate and staminate flowers of which it is constituted. The vegetative characters, with their great multiplicity of form, are next taken up, and their striking similarity in many cases to the Cacti, to which they are entirely unrelated, either phylogenetically or geographically, is pointed out; in spite of the vegetative variability, the relatively uniform structure of the cyathium has been maintained. The last part of the introduction is devoted to a historical discussion of the group.

There are keys to the above-mentioned three genera, and then to 193 species of the genus *Euphorbia.* Each of these species is subsequently taken up in very considerable detail, with complete descriptions of the plant, the spines, the leaves, the inflorescence and the capsules. Next follow type locality and distribution. After these formal accounts, in each case there is a discussion of history, relationships, growth habits, geographical occurrence, etc. These informal presentations are prepared in delightful style and give the volumes life and charm. Two species of *Monadenium* and two of *Synadenium* are similarly considered.

The first Appendix, A, lists the new species, varieties and combinations proposed in the book and gives Latin descriptions when necessary. In all, thirteen new species, fifteen new varieties, seven new combinations and one change of name are offered. A glossary, bibliography, discussion of five undetermined species and "Notes on Euphorbia Culture" conclude these volumes.

One of the most striking features of this work is the illustrations. In all, one hundred and ninety-seven species are described, and there are more than eleven hundred figures, including seventy in the introduction. Most of the species, therefore, are illustrated by a number of figures. In addition, there are twenty-five plates in full color.

Even if you are among the uninitiated, you can turn through these pages and gain a conception of what this group is like from the illustrations. And if you do, you will read some of the accounts, and you will be impressed by the polish, and in some instances by the quaintness, with which they are presented.

"The Succulent Euphorbieae" is a monument, of which the authors may well be proud.

The Carnivorous Plants. By FRANCIS ERNEST LLOYD. xvi + 352 pp. 11 figs. + 38 plates. Waltham, Mass.: Chronica Botanica Company. 1942. $6.00.

ALTHOUGH other accounts of carnivorous and in-

[1] *Jour. Am. Chem. Soc.,* 39: 1848, 1917.

[2] Vol. 39, p. 717, 1924.

sectivorous plants have been written, the lack of a recent and comprehensive treatment of these plants would in itself make the present volume worth while. When to this is added the intensive research of the author for more than a decade, "The Carnivorous Plants" becomes an especially valuable book. Professor Lloyd states in the preface that his interest in these plants began with work on *Utricularia gibba*, but that the treatise under consideration is based on material collected and received from many sources.

There is one relatively short chapter on carnivorous fungi, in which we read of "loop snares," "eel-bob snares" and "adhesive organs." Each of the other thirteen chapters deals with one or more of the fifteen angiospermous genera that stoop to conquer flesh—often, though by no means always, that of insects. These fifteen genera, which occur in six different families, include some 450 species, of which, however, *Utricularia* has 275, *Drosera* 90 and *Nepenthes* 65. Five of the genera are monotypic.

The kinds of traps, in addition to the snares of the fungi, are classified as "pitfalls" (pitcher plants) as in *Sarracenia, Darlingtonia, Nepenthes,* etc., "lobster pot" as in *Genlisea,* "bird lime or fly-paper traps"—passive as in *Byblis* and *Drosophyllum,* active as in *Pinguicula* and *Drosera,* "steel-trap" as in *Dionaea* and *Aldrovanda,* and "mousetrap" as in *Utricularia,* etc. Lures are also present, which may take the form of odors in *Sarracenia* and *Drosophyllum,* nectar secretion in *Nepenthes,* attractive colors in *Sarracenia* and *Darlingtonia* and of brilliant points of reflected light in *Pinguicula* and *Drosera.*

Each of the chapters is really an intensive study of the structure, development, mechanisms and interpretations of the various genera. The treatment accorded to *Drosera* and *Utricularia* is especially inclusive, a separate chapter of thirty-eight pages being devoted to the *Utricularia* trap. The literature cited at the end of each chapter is extensive; this indicates the interest that these plants have aroused for a very long time and testifies to the assiduity of the author. In addition to eleven text figures, there are thirty-eight plates, each with numerous illustrations.

Every one who reads about these plants wants to know whether their carnivorous habits really benefit them. This topic is discussed in detail in the chapter on *Drosera,* and abundant evidence for the affirmative conclusion is assembled. In the introduction also this subject is considered. "From the purely physiological point of view the carnivorous plants are concerned in a somewhat special way in the acquisition of nutrient substances containing protein, possibly vitamins and perhaps the salts of potassium and phosphorus, and even others. In this way they receive some profit, though what they receive is no *sine qua non,* as it is with many other plants."

Professor Lloyd has written a scholarly, complete, authoritative volume—one that will take its place fittingly on the library shelf beside Charles Darwin's "Insectivorous Plants," published in 1873. The author writes with clarity, with conviction and on occasion with a touch of humor. And if, at times, his presentation seems intricate and involved, as in the *Utricularia* trap, so is the subject.

EDWIN B. MATZKE

COLUMBIA UNIVERSITY

REPORTS

MEDAL DAY AT THE FRANKLIN INSTITUTE

AN American and a Russian scientist share the highest honors of The Franklin Institute this year. The selection of Dr. William David Coolidge, vice-president and director of research for the General Electric Company; and Dr. Peter Kapitza, director of the Institute for Physical Problems, Academy of Sciences, Union of Soviet Socialist Republics, to receive the Franklin Medal was based upon work in physical science or technology, without regard to country, which in the opinion of the institute, acting through its Committee on science and arts, has done most to advance a knowledge of physical science or its applications.

Dr. Coolidge received the Franklin Medal "in recognition of his scientific discoveries, which have profoundly affected the welfare of humanity, especially in the field of the manufacture of ductile tungsten and in the field of improved apparatus for the production and control of x-rays"; and Dr. Kapitza "in recognition of his remarkable contributions to experimental physics and also to theoretical physics, especially in the fields of magnetism and low temperatures."

Since the founding of the Franklin Gold Medal in 1914, the face of which carries a medallion of Benjamin Franklin done from the Thomas Sully portrait of Franklin owned by The Franklin Institute, it has been awarded by the institute to such figures as Thomas A. Edison, Guglielmo Marconi, Charles Fabry, Pieter Zeeman, James H. Jeans, Orville Wright, Albert Einstein and Charles F. Kettering.

Dr. Coolidge has won many scientific awards, among them the Howard N. Potts and the Louis Edward Levy Medals of The Franklin Institute, and an honorary M.D. degree from the University of Zurich. Interested in mechanical problems and principles since his

youth on a farm in Hudson, Mass., Coolidge won a scholarship to the Massachusetts Institute of Technology in 1895. Upon graduating from that institution he continued his studies abroad and in 1899 was awarded his Ph.D. at the University of Leipzig. After six years of research work and teaching he accepted a research position in the physical chemistry laboratories of the General Electric Company.

His x-ray tube has changed x-ray technique from an art to a science, enormously extending the range, utility and effectiveness of x-rays. In developing the x-ray tube from an inexact device to its present form —a tube with the highest possible vacuum in which an electron stream from a filament, heated by an auxiliary current, can be directed upon a tungsten target by a separately controlled voltage—he has completely revolutionized the use of x-rays, creating the science of radiology. He has developed the tube to a point where it can operate on much higher voltages. The greater penetrating power which results is now used in cancer research. In achieving this, Coolidge applied the cascade principle, which is now used in equipment for radiographic examination of steel castings and welds, to discover internal defects.

The modern incandescent lamp, because of Coolidge's development of the drawn tungsten filament and Langmuir's contribution of filling the lamp with gas, has saved our country over a billion dollars a year in lighting bills. Tungsten, always a brittle metal because of its crystalline structure, became both ductile and fibrous as a result of Coolidge's researches and tireless effort.

From his home in Schenectady, N. Y., Coolidge sent a daughter to study and then teach biology; she later married a biologist. His son is studying economics at Columbia University. Hobbies interesting Dr. Coolidge are color photography, both still and motion picture, and astronomy. Impatient of carelessness or superficiality because of his own perceptive qualities of mind which go quickly to essential and crucial facts, he nevertheless possesses a keen sense of humor. It is understandable to consider Coolidge the 1940 selection of the National Association of Manufacturers as one of the "Modern Pioneers," and a winner of the Duddell Medal of the Physical Society of London. He is a member of many scientific societies and organizations.

Peter Kapitza, the son of the late General Leonid Kapitza of the Russian Imperial Army, was born at Kronstadt, Russia, in June, 1894. Electrical engineering training at Petrograd Polytechnical Institute was followed by further study at Cambridge University, England. From 1924 until 1932 Kapitza was assistant director of magnetic research at the Cavendish Laboratory, Cambridge, England. He held the Royal Society Messel research professorship as well as being director of the Royal Society Mond Laboratory for research at low temperatures. The Franklin Institute awarded him a Franklin Medal in 1944 " in recognition of his remarkable contributions to experimental physics and also to theoretical physics, especially in the fields of magnetism and low temperatures."

Dr. Kapitza's great work has been the invention of a method of producing extraordinarily high magnetic fields, many times greater than were previously thought possible, and the development of ingenious methods for making magnetic measurements of various kinds upon small pieces of matter exposed for a small fraction of a second to such fields. The results obtained provide important information about the structure and the behavior of the atoms of ferromagnetic, paramagnetic and diamagnetic substances.

He also designed and constructed a machine for making liquid air and liquid hydrogen which is much more efficient and smaller than any machine yet developed. It is believed that the Russian Army has used liquid air and applications of Kapitza's researches for military purposes.

Other prominent men in scientific and industrial fields who received medals at The Franklin Institute Medal Day ceremonies include Dr. Roger Adams, head of the department of chemistry (now on leave), University of Illinois, Urbana, Illinois. Dr. Adams received the Elliott Cresson Medal award for his notable work in organic chemistry.

The John Price Wetherill Medal was awarded, posthumously, to Richard C. duPont, president, All American Aviation, Inc., Wilmington, Del., "for his development of a successful and practical 'on the wing' air mail and glider pick-up apparatus"; and to Willem Fredrik Westendorp, Research Laboratory, General Electric Company, Schenectady, N. Y., "for his development of a successful high-voltage, low-frequency resonance transformer of relatively small size and light weight, which is shock-proof, efficient in operation and particularly suitable for use in high voltage portable x-ray units."

Two Philadelphians, Frank B. Allen and J. Stogdell Stokes, of the Allen-Sherman-Hoff and Stokes-and Smith companies, respectively, were awarded the Edward Longstreth Medal, Allen, for the development of the hydroseal pump, and Stokes for developing new machinery used in making paper boxes. Edward E. Simmons, Jr., of Sacramento, Calif., was awarded the Edward Longstreth Medal for his invention of the SR-4 Strain Gage, now in wide industrial use.

The Frank P. Brown Medal was awarded to Dr. Harvey Clayton Rentschler, director of research, Lamp Division, Westinghouse Electric and Manufacturing Company, Bloomfield, N. J., "in consideration of his application of a source of bactericidal radiation

in air conditioning systems in a scientific and practical manner."

Dr. Walther Emil Ludwig Mathesius, president and director of the Geneva Steel Company, Geneva, Utah, received the Francis J. Clamer Medal for outstanding achievements in the field of metallurgy, particularly for contributions in blast furnace practice.

The George R. Henderson Medal was awarded to Joseph Burroughs Ennis, senior vice-president, American Locomotive Company, New York, "in consideration of his accomplishments in locomotive engineering and important contributions in the field of locomotive design."

For his paper on "The Theory of Suspension Bridges," which appeared in the March and April, 1943, issues of the *Journal of the Franklin Institute,* Professor Stephen P. Timoshenko, department of theoretical and applied mechanics, Stanford University, Palo Alto, Calif., was awarded the Louis E. Levy Medal.

A Certifiicate of Merit was given to the Western Union Telegraph Company, New York, "for the development of the reperforator switching system, a contribution to the greater accuracy and speed of telegraphic service."

HENRY BUTLER ALLEN,
Secretary and Director, the Franklin Institute

SPECIAL ARTICLES

THE INFLUENCE OF IRON OXIDE ON WEAR OF RUBBING SURFACES

IN the course of an investigation of wear under boundary lubrication the condition was produced which permits hard and soft ferrous surfaces to rub under very heavy loads at a moderate speed without rapid wear despite the absence of special wear-inhibitors in the hydrocarbon lubricant. The tenacious layers of iron-oxide which slowly develop under the lubricant and cover the rubbing surfaces were studied with the aid of a microscope and their ability to reduce wear was related to the hardness or imbedability of the surfaces. The following summarizes some of the experiments:

In the first experiments a modified Timken machine[1] was used, in which a stationary block of mild steel or of cast-iron, with a wearing face measuring one by ten millimeters was aligned with its longer edge perpendicular to the direction of rotation of a polished hard steel cylindrical ring measuring five centimeters in diameter by ten millimeters wide. The ring was turned upon its axis with a peripheral speed of 209 centimeters per second while pressure was applied to the block and a plentiful supply of lubricant flowed over both parts.

Failure due to the adhesion and transfer of metal from the block to the ring by welding would occur instantly unless the apparent bearing pressure was very light (20 to 30 kg/cm^2). If the initial pressure was gradually increased from this low figure, a worn-in state could be developed, in the course of several days, whereby a pressure of 2 or 3 thousand kilograms per square centimeter could be borne without failure. Wear-in or break-in was materially assisted by frequently repolishing the ring to remove particles of metal which had been transferred to it. No attempt was made to polish the block. After the break-in process was complete, welding ceased and further polishing was not necessary.

The rate of wear of a properly broken-in mild-steel or cast-iron block was so low that no loss of weight could be detected by reweighing the block to 0.2 mg after a day or two of high-pressure operation (2,000 to 3,000 kg/cm^2). In some experiments a slight gain in weight of both the ring and the block was noticed after prolonged operation; this is attributed to the accumulation of iron-oxide.

In further experiments similar attempts to break-in hard steel blocks were unsuccessful; failure occurred from seizure at pressures below 800 kg/cm^2.

Observations of a similar type were made during experiments with the four-ball wear machine, an adaptation of Boerlage's apparatus.[2] In this machine, three stationary balls of hard steel, of cast iron or of mild-steel clamped in a cup and covered with the lubricant, were pressed upward with a measured force against a hard steel ball spinning on a vertical axis. When heavy loads (60 kg or more) were applied, there was an immediate transfer of metal to the spinning ball, and rapid wear of the stationary balls occurred when an ordinary mineral oil was the lubricant at these loads. However, with a very light load (7 kg), no welding was observed; the sliding action appeared to be smooth, and the wear occurring could be determined by measuring scar diameters at predetermined intervals of time. Such measurements are given in Table 1.

During the break-in period the contact areas of the soft stationary balls rapidly expanded, probably by plastic flow, until the contact pressures reached the approximate range of 2,000 to 3,000 kg/cm^2, depending upon temperature. However, the scars in the more elastic stationary balls did not expand so rapidly

[1] Timken Roller Bearing Company, Canton, Ohio.

[2] *Engineering,* 136: 46, 1933; 144: 1, 1937.

at first, but wore continuously until at length they had become much larger, and the pressures much smaller than in the softer balls.

The red and brown material reported in the table has been identified as iron-oxide produced in the wearing areas by friction-oxidation. Microscopic observation revealed that the oxide became imbedded in the softer metals but not in hard steel. Well-established iron-oxide deposits were also observed on the broken-in mild-steel and cast-iron wear blocks of the Timken machine, but not on the hard steel blocks which failed to break-in. The observations indicate that the presence of these oxide layers on soft metal balls must have contributed materially to the low rate of wear after break-in, and the absence of oxide from hard steel balls permitted continuous wear without the occurrence of break-in.

It is apparent from the work of Bowden, Hughes and Whittingham[3] that fresh ferrous surfaces operate in danger of seizure owing to the high coefficient of boundary friction; such seizure results in the establishment of metal bridges which have the shear strength of the metal involved. On the other hand, if a contaminating film of oxide, sulfide, halide, etc., exists, shearing occurs along the plane of the mechanically weaker contaminant and friction is reduced.

The experiments of Bowden and Tabor[4] indicate that the area of intimate contact of lightly loaded sliding surfaces is very small, and at local areas the pressure may exceed the elastic limit and cause steel to flow plastically. It would seem, therefore, that despite the light initial load, local conditions in the Timken machine were essentially the same as in the four-ball machine where the calculated initial contact pressure at 7 kg load approached the elastic limit of the hard, and far exceeded that of the soft steel balls.

TABLE 1

THE RELATIVE RATES OF WEAR OF HARD AND SOFT STATIONARY BALLS IN THE FOUR-BALL WEAR MACHINE

Conditions: Speed, 700 rpm (31 cm/sec); load, 7 kg; lubricant, SAE 20 motor oil, air saturated; rotating ball of hard steel, stationary balls as listed.

Elapsed minutes operation	Mild steel stationary balls (200 Brinell)			Cast-iron stationary balls (230 Brinell)			Hard steel (SKF) stationary balls (630 Brinell)		
	Average diameter of six scars, mm	Scar pressure kg/cm²	Appearance of scars*	Average diameter of six scars, mm	Scar pressure kg/cm²	Appearance of scars*	Average diameter of six scars, mm	Scar pressure kg/cm²	Appearance of scars*
Lubricant Temperature, 30° C.									
5	.316	3,640	Reddish brown	.282	4,580	Reddish-brown	.214	7,950	Polished steel
10	.336	3,220	"	.292	4,270	"	.225	7,190	"
20	.349	2,990	"	.310	3,790	"	.254	5,640	"
40	.340	3,150	Brown	.322	3,510	"	.272	4,920	"
80	.344	3,250	"	.342	3,110	"	.347	3,020	"
160	.340	3,150	Dark brown	.345	3,060	"	.431	1,960	"
320	.341	3,130	"	.340	3,150	"	.437	1,910	Slightly reddish
640	.373	2,620	"	.390	2,390	"	.438	1,900	Reddish-brown
Lubricant Temperature, 130° C.									
5	.499	1,460	Reddish-brown	.413	2,130	Reddish-brown	.332	3,300	Polished steel
10	.518	1,360	"	.425	2,010	"	.395	2,330	"
20	.525	1,320	"	.434	1,930	"	.486	1,540	"
40	.528	1,310	"	.450	1,800	"	.601	1,010	"
80	.547	1,220	"	.484	1,550	"	.701	741	"
160	.598	1,020	"	.544	1,230	"	.763	625	"
320	.633	908	"	.565	1,140	"	.893	456	"
640	.645	875	"	.584	1,070	"	1.04	336	"

* Dark field illumination at 30 or 60 diameters.

The mechanism controlling the surface events which determine whether a new bearing shall fail or shall become broken-in to carry heavy loads is visualized as follows: At low initial loads where the destruction of the bearing surface by seizure can be avoided, the heat of mild rubbing accelerates the oxidation of iron in the surface by oxygen dissolved in the lubricant. If the surface is imbedable, the resulting oxide becomes established as a protective layer in much the same way as reported by Eichinger for unlubricated surfaces.[5] Rubbing now occurs over the oxide layer and the ferrous surface beneath is thus prevented from having direct contact with oxygen activated by rubbing. Hence further friction-oxidation decreases to the vanishing point.

Hard steel surfaces, not being receptive to foreign materials, remain bare during rubbing and subject to attack by oxygen, leading to continuous removal of metal or wear. On the other hand, the softer metals

[3] Bowden and Hughes, *Proc. Roy. Soc.*, A–172: p. 263, 1939. Hughes and Whittingham, *Trans. Faraday Soc.*, 38: p. 9–27, 1942.

[4] Bowden and Tabor, *Proc. Roy. Soc.*, A–169: 391–413, 1938.

[5] Eichinger, Eidgenöss. Materialprufüngs-u. Versuchsanstalt Ind., Bauw. Gewerbe, Zurich Diskussionsber No. 121, 32 pp., 1938.

become coated and resistant to further wear, as the data illustrate.

Wells A. Webb

Shell Development Company,
Emeryville, California

ISOLATION OF A NEW LACTOBACILLUS CASEI FACTOR

Snell and Peterson[1] first presented evidence for the existence of a new growth factor (the "norite eluate" factor) for *Lactobacillus casei*. Mitchell, Snell and Williams[2] reported the concentration of a factor ("folic acid") from spinach. This factor was active for both *Streptococcus lactis* R and for *L. casei*. Hutchings, Bohonos and Peterson[3] showed that purified concentrates of the "norite eluate" factor from liver stimulated the growth of *Lactobacillus helveticus, Lactobacillus delbruckii, Propionibacterium pentosaceum* and *Streptococcus lactis* R.

Since then a number of different compounds have been described which are active in stimulating the growth of *L. casei* or *S. lactis* R. Pfiffner[4] *et al.* reported the isolation from liver of a crystalline compound which was active for *L. casei*. This substance which they designated vitamin B_c was also active in preventing anemia and in promoting growth in chicks. Stokstad[5] described two compounds; one was obtained from liver and the other from yeast. That obtained from liver was thought to be identical with the compound obtained by Pfiffner *et al.* The free acids of the compounds obtained from liver and yeast had equal potency for *L. casei*. However, when assayed with *S. lactis* R the preparation from yeast was only half as active as from liver. Both the factors from liver and yeast appear to be different from the growth factor for *S. lactis* R described by Keresztesy *et al.*[6] Their preparation was approximately 2,500 times as active for *S. lactis* R as for *L. casei*.

In this communication we wish to report the isolation in crystalline form of a new compound which is active for *L. casei* and *S. lactis* R and is also active in the nutrition of the chick. This new compound was crystallized as the barium salt, as the free acid and as the methyl ester. The barium salt crystallized as needles, the free acid and the ester crystallized as small needles or threads. The absorption spectrum in 0.1 N NaOH was very similar to the compound isolated from liver (Table 1). It will be noted that the $E_{1\,cm}^{1\,per\,cent.}$ was less for the new compound, being only 86 per cent. as great at 365 mμ.

TABLE 1
Comparison of Absorption Spectra

	New compound		Liver compound		Ratio
	mμ	$E_{1\,cm}^{1\,per\,cent.}$	mμ	$E_{1\,cm}^{1\,per\,cent.}$	$E_{1\,cm}^{1\,per\,cent.}$ New compound / $E_{1\,cm}^{1\,per\,cent.}$ Liver compound
Maxima ...	259	317	255	440	0.72
Minima ...	266	305	267	376	0.81
Maxima ...	280	333	283	425	0.78
Minima ...	332	92	331	103	0.89
Maxima ...	365	130	365	151	0.86

This new compound was 85 to 90 per cent. as active as that from liver when assayed with *L. casei*, but only 6 per cent. as active as the liver compound by *S. lactis* R assay. The amounts of the liver compound required for half-maximum growth were 0.000055 micrograms per ml for *L. casei* and 0.00025 micrograms per ml for *S. lactis* R. The new compound was required in amounts of 0.000061 micrograms per ml for *L. casei* and 0.0042 micrograms per ml for *S. lactis* R.

On the basis of their absorption spectra the three *L. casei* factors (present compound, liver and yeast factors) appear to be different from "folic acid." The $E_{1\,cm}^{1\,per\,cent.}$ for this new compound and the liver *L. casei* factor were determined at pH 11.0 and compared with the data at the same pH reported by Mitchell[7] (Table 2). The wave-lengths chosen do not represent maxima or minima but were used to correspond with the wave-lengths reported for folic acid.

TABLE 2
Comparison of $E_{1\,cm}^{1\,per\,cent.}$ at pH 11.0 of the L. casei Factors and Folic Acid

	New compound	Liver compound	Folic acid
mμ	$E_{1\,cm}^{1\,per\,cent.}$	$E_{1\,cm}^{1\,per\,cent.}$	$E_{1\,cm}^{1\,per\,cent.}$
260	296	404	338
280	336	410	190
300	245	334	102
380	121	125	92

B. L. Hutchings
E. L. R. Stokstad
N. Bohonos
N. H. Slobodkin

Lederle Laboratories, Inc.,
Pearl River, N. Y.

[1] E. E. Snell and W. H. Peterson, *Jour. Bact.*, 39: 273, 1940.
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[7] H. K. Mitchell, *Jour. Am. Chem. Soc.*, 66: 274, 1944.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A CHEMICALLY DEFINED MEDIUM FOR THE CULTIVATION OF THE GONOCOCCUS[1]

A FLUID medium comprising 9 organic acids, 5 inorganic salts and glucose has been developed for the growth of the gonococcus. It contains 7 organic acids in addition to those required by the meningococcus as reported by Frantz.[2] The composition is as follows:

	Grams per liter
d-Glutamic acid[3]	1.3
dl-Leucine[3]	0.40
l-Arginine monohydrochloride[3]	0.25
l-Histidine monohydrochloride[3]	0.15
dl-Methionine[3]	0.15
l-Proline[3]	0.10
Glycine[4]	0.05
l-Cystine[4]	0.01
Indole-3-acetic acid[4]	0.10
NaCl[5]	6.0
$NaH_2PO_4 \cdot H_2O$[5]	2.5
NH_4Cl[5]	1.25
$Mg(NO_3)_2 \cdot 6H_2O$[5]	0.05
$FeSO_4$[5]	0.012
Glucose[4]	5.0

With the exception of glucose, indole acetic acid, ferrous sulfate and magnesium nitrate, the constituents are added to 950 ml of distilled water. The pH of the mixture is adjusted with normal sodium hydroxide to from 6.8 to 7.0, and then autoclaved at 121° C for 10 minutes in a pyrex-glass container. After cooling to room temperature, 25 ml of a sterile 20-per cent. glucose solution are introduced into the medium. One per cent. solutions of ferrous sulfate, magnesium nitrate and indole acetic acid are added separately in the following volumes, respectively; 1.2 ml, 5.0 ml and 10.0 ml. The pH is finally readjusted to from 7.0 to 7.2.

Five ml of the medium were inoculated with one loopful of washed gonococcal cells obtained by centrifugation from a 24-hour Douglas's broth culture. Incubation was carried out at 37° C in an atmosphere containing approximately 10 per cent. of carbon dioxide. The method of introducing 10 per cent. tank carbon dioxide as described by Leahy and Carpenter[6] gave better results than the method of burning a candle to self-extinction. The gaseous mixture was replaced at daily intervals.

Sixty strains of *Neisseria gonorrhoeae* were employed for the development and testing of this medium. Both recently isolated strains and those subcultured for several years were included. Not all strains grew equally well and approximately 25 per cent. did not grow either in the synthetic medium or in Douglas's broth. Growth was maximal after 2- to 3-days' incubation. At this time, 5.0 ml of the medium contained, on the average, 0.25 mg of bacterial nitrogen, which is equivalent to 2.0 mg of gonococcal cells. The growth was more than double that obtained in Douglas's broth under the same conditions. The cells remained viable for at least 5 days. Cultures transferred every third day have been maintained readily for 3 months.

The final concentration of each substance in the medium was determined on the basis of maximal growth of the majority of the strains tested. The concentrations of glycine, cystine, ferrous sulfate and of both ions of magnesium nitrate were critical. The amount of the other substances employed in the medium permitted of some variation. Divalent lead and trivalent iron salts in concentrations of 10 micrograms per ml favored the growth of certain strains. The manganous ion, in a concentration of 5 micrograms per ml was toxic for the gonococcus. The cupric ion was also toxic but only at concentrations greater than 5 micrograms per ml.

Growth of the strains which otherwise failed to grow in the medium above described was obtained in almost every instance when glutamine[7] and choline were incorporated in the medium in concentrations of 0.2 mg and 0.1 mg per ml, respectively.

Studies to determine the more rigid requirements of certain primary cultures of *Neisseria gonorrhoeae* are in progress.

JANE PLACK WELTON
HERBERT E. STOKINGER
CHARLES M. CARPENTER

SCHOOL OF MEDICINE AND DENTISTRY,
UNIVERSITY OF ROCHESTER

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[2] I. D. Frantz, *Jour. Bact.*, 43: 757, 1942.

[3] We are indebted to Merck and Company, Incorporated, Rahway, N. J., for certain of the synthetic amino acids.

[4] Eastman Kodak Company, Rochester, N. Y.

[5] J. T. Baker Chemical Company, Phillipsburg, N. J.

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